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## Original article

## Population monitoring and annual population fluctuation of migratory and resident species of vultures in and around Jodhpur, Rajasthan

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## A B S T R A C T

Vultures are important scavengers that play a vital role in clearing animal carcasses and municipal dumps. In the past decade, a sharp decline has been observed in vulture population. For the present work, Jodhpur district of Thar Desert, India, the natural habitat of resident and migratory species of vultures, was investigated. Intensive surveys of the study area were undertaken from 2007 to 2015 to determine the annual population fluctuations in various vulture species in and around Jodhpur (26°19'N and 73°08'E). The data obtained regarding the population fluctuation of different vultures species in the study area are of great significance. Comparative analysis of data obtained with regard to the population dynamics of the various species of vultures in this region has suggested that there has been a drastic decline in the population of migratory as well as resident vulture species in this region. A comparative study suggests that the population of migratory species has reached very low relative abundance in 2015 as compared to 2007. *Neophron percnopterus* has the highest and *Gyps bengalensis* has the lowest population during the entire 9-year study. The finding suggests that the reason for this population fluctuation is climate change as well as change in temperature fluctuation over a period of time, particularly during the breeding season.

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## Introduction

Vultures are one of the most important scavengers as they provide an important ecosystem service by disposing of waste carrion from dead cattle. Owing to a lot of variation in geographical and environmental gradient, India has nine species of vultures in the wild (Ali and Repley 1987), of which four species—*Gyps bengalensis*, *Gyps indicus*, *Sercogyps calvus*, and *Gyps tenuirostris*—are listed as critically endangered in the International Union for Conservation of Nature Red Data Book (IUCN 2016). There has been a drastic decline in vulture population in the Indian subcontinent over the past two decades (Rahmani 1998; Prakash 1999; Prakash and Rahmani 1999; Virani et al 2001; Prakash et al 2003; Chhangani 2005; Gilbert et al 2006). Thar Desert, one of the smallest deserts in the world, lies between 25° and 30°N (latitude) and 69.5° to 76°E (longitude) (Rahmani 1997). Jodhpur, the part of Thar Desert situated at 26°19'N latitude and 73°8'S longitude, has

the dry and hot climate conditions of the desert, exhibiting xerophytes vegetation, which is favorable for nest building among resident species such as Egyptian vulture, long billed vulture, and white backed vulture (Chhangani 2002).

Eurasian griffon, Himalayan griffon, and cinereous vultures migrate here at Jodhpur to avoid adverse conditions at their native places. The population explosion in Jodhpur has generated several new challenges in terms of habitats and food availability, affecting the eco-status of vulture species in Jodhpur (i.e., Keru, Badli, and Arna Jharna). A dramatic fall in their population has created serious challenges, in particular, carcass disposal and the consequent rapid increase in the canine population. Compounding the issue, vulture populations on the Indian subcontinent have undergone dramatic (>95%) declines and carcasses that would normally be consumed by vultures now supplement dog diets (Markandya et al 2008; Prakash et al 2003).

Monitoring vulture population size is often a strenuous task as most species are territorial and widely distributed over a sizable area (Fuller and Mosher 1981). Different species of vultures show local seasonal fluctuations, and their number and activity may vary throughout the day or within a season (Newton 1979). Vultures are large gregarious species that breed colonially in cliffs, forming large

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nesting groups (Cramp and Simmons 1980; Mundy et al 1992). Monitoring techniques consist of counting birds at their breeding or roosting sites early in the morning or late in the evening prior to or after their daily foraging trips (Robertson and Boshoff 1986; Marincovic and Orladie 1994; Borello and Borello 2002). The movement of vultures depends on environmental conditions and food availability, and it is directly related to vulture movement to find food, frequency of thermals, and temperature (Somayeh et al 2014).

The conservation of threatened vulture species require reliable and robust assessments of long-term demography so as to visualize proper management. Population dynamics can be understood as the outcome of addition (births and immigration) and loss (death and emigration) of individuals from a population. In this study, we combined an unrivaled large collection of dynamics and population data over a 10-year period, and included a geographical distinct population with large-scale dataset to assess the direct effect of external environment conditions on the movement ecology of resident and migratory avian scavengers.

The aim of the present study was to investigate the annual fluctuations in the size of resident and migratory vultures in and around Jodhpur as relevant published accounts are lacking. The intensive surveys of the study area were undertaken from 2007 to 2015 to determine the annual population fluctuations in various species of vultures. The ultimate goal was to improve population monitoring schemes so that future surveys in the Thar Desert could be undertaken in a meaningful time and comparisons between population estimates become reliable. Possible key elements that affects vulture population in the Thar desert were also established.

## Materials and methods

### Study area

The study site of the present investigation was Jodhpur (26°17'59"N and 73°02'02"E), which is situated in the western part of Rajasthan and is a prominent part of the great Indian Thar Desert. Topographically, it is by and large plain and open, and occasionally interrupted by hillocks. Throughout the year, the average temperature ranges from 6°C to 45°C, whereas in May and June it can reach

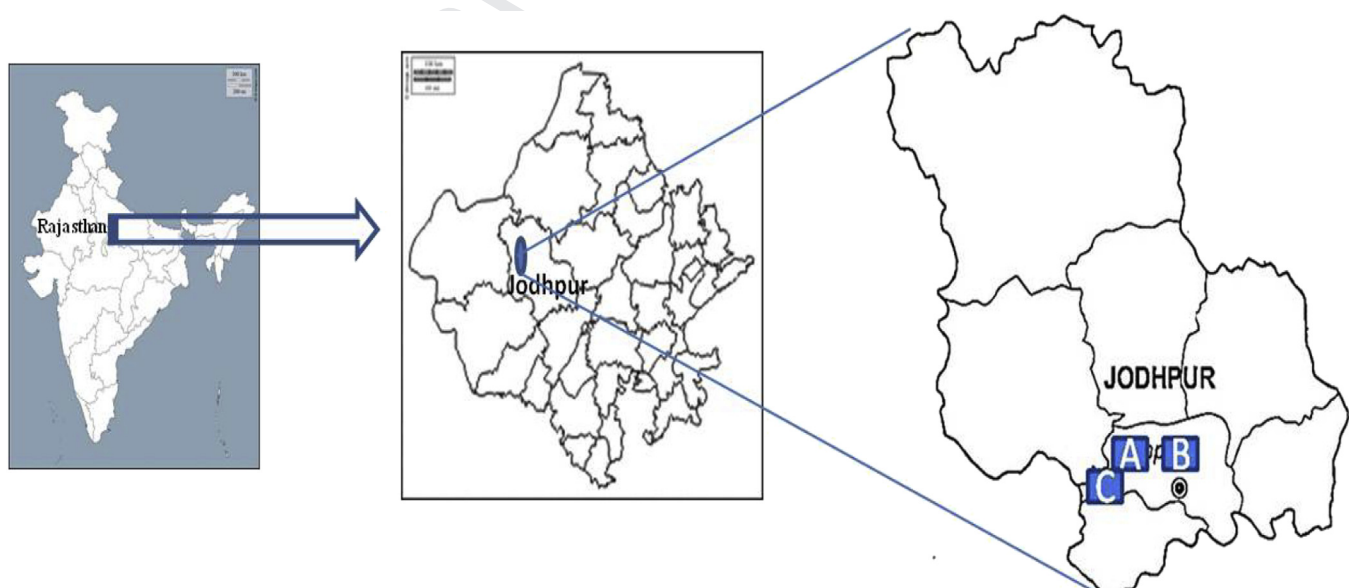
up to 49°C. The annual average rainfall is 300 mm, distributed over 20 rainy days. This wide range of climatic conditions attracted vulture species to establish their habitat types in and around the city of Jodhpur. The study area (Jodhpur region) was selected because of the maximum availability of vulture populations compared with other parts of the Thar desert (Figure 1). Within Jodhpur, Keru (Figure 2A), Badli pond (Figure 2B), and Arna Jharna (Figure 2C) are the major habitat sites for vultures because they provide access to lake water and carcasses (dead animal dumping sites) throughout the year.

### Experimental details

An intensive study was carried out at Keru, Badli pond, and Arna Jharna (in Jodhpur) from November 2007 to December 2015 to determine the population and ecological specificities of the vulture species. To have an accurate estimation of the annual fluctuation in a population of vultures, regular monitoring was conducted for counting of birds, which started from early morning to late afternoon from November 2007 to December 2015. All visits to observe seasonal variation were conducted every other day so as to cover all fluctuations homogeneously; more attention was given on feeding site counting because of the availability of all species for a longer time at the feeding station. Annual fluctuations in the colony were examined by assessing vulture numbers in nesting sites from sunrise to sunset from November 2007 to December 2015 at a rate of 12–20 visits per month. During these daylong observations, the maximum number of birds present in selected sites was recorded rotationally at 60-minute intervals (scan sampling; Bateson and Martin 1990). Departure time was the moment in which more than 50% of the vultures in the colony left the study site, whereas arrival time was the moment in which at least two-thirds of the birds counted in the morning returned to the selected site assuming that the transect routes covered all the sites under study.

### Statistical analysis

Linear regression in Microsoft Excel 2016 was used to determine a trend in the population of resident (*G. indicus*, *G. bengalensis*, and



**Figure 1.** Study area used to determine annual population fluctuation of resident and migratory vulture species. The present study was conducted at three sites. A, Keru dumping station. B, Badli pond. C, Arna Jharna. All three sites are located in and around Jodhpur district (as indicated in the map, up right), Rajasthan, India. (Reproduced with due permission and acknowledgment from <http://d-map.com> on December 11, 2016.)

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